

# Outcomes of tetralogy of Fallot reoperation in adults: a single-center experience with bioprosthetic pulmonary valve replacement

Grzegorz Wasilewski<sup>1</sup>, Bogdan Suder<sup>1</sup>, Anna Kędziora<sup>1</sup>, Radosław Litwinowicz<sup>1</sup>, Piotr Mazur<sup>1</sup>, Lidia Tomkiewicz-Pająk<sup>2</sup>, Bogusław Kapelak<sup>1</sup>

1 Department of Cardiovascular Surgery and Transplantology, Institute of Cardiology, Jagiellonian University Medical College, John Paul II Hospital, Kraków, Poland

2 Department of Cardiovascular Diseases, Institute of Cardiology, Jagiellonian University Medical College, John Paul II Hospital, Kraków, Poland

**Introduction** Tetralogy of Fallot (ToF) is the most common cyanotic congenital heart disease.<sup>1</sup> Symptoms are present at birth and may vary from mild to severe. Significant survival improvement is observed following surgical ToF correction, which leads to late complications in survivors, such as progressive exercise intolerance, arrhythmias, heart failure, and sudden cardiac death.<sup>2</sup> A reoperation may be necessary in individuals with right ventricular (RV) failure due to pulmonary valve dysfunction. Pulmonary valve replacement (PVR) is the treatment of choice in this clinical setting; however, data to support the choice of prosthesis are sparse.<sup>2</sup> Good outcomes were reported with the use of bioprosthetic valves, but the clinical observations are limited. This prompted us to present the first Polish experience with ToF reoperations comprising PVR with a bioprosthesis.

**Methods** A total of 27 consecutive patients with a history of ToF repair in childhood were referred for reoperation in the Department of Cardiovascular Surgery and Transplantology, Institute of Cardiology, Jagiellonian University College of Medicine, John Paul II Hospital, Kraków, Poland, between 2012 and 2018. Four patients were previously reoperated, but none of them had PVR. Patients were included if indications for reoperation were satisfied (symptomatic deterioration and/or progressive RV dysfunction), as assessed by the local Grown-up Congenital Heart Disease Heart Team, in

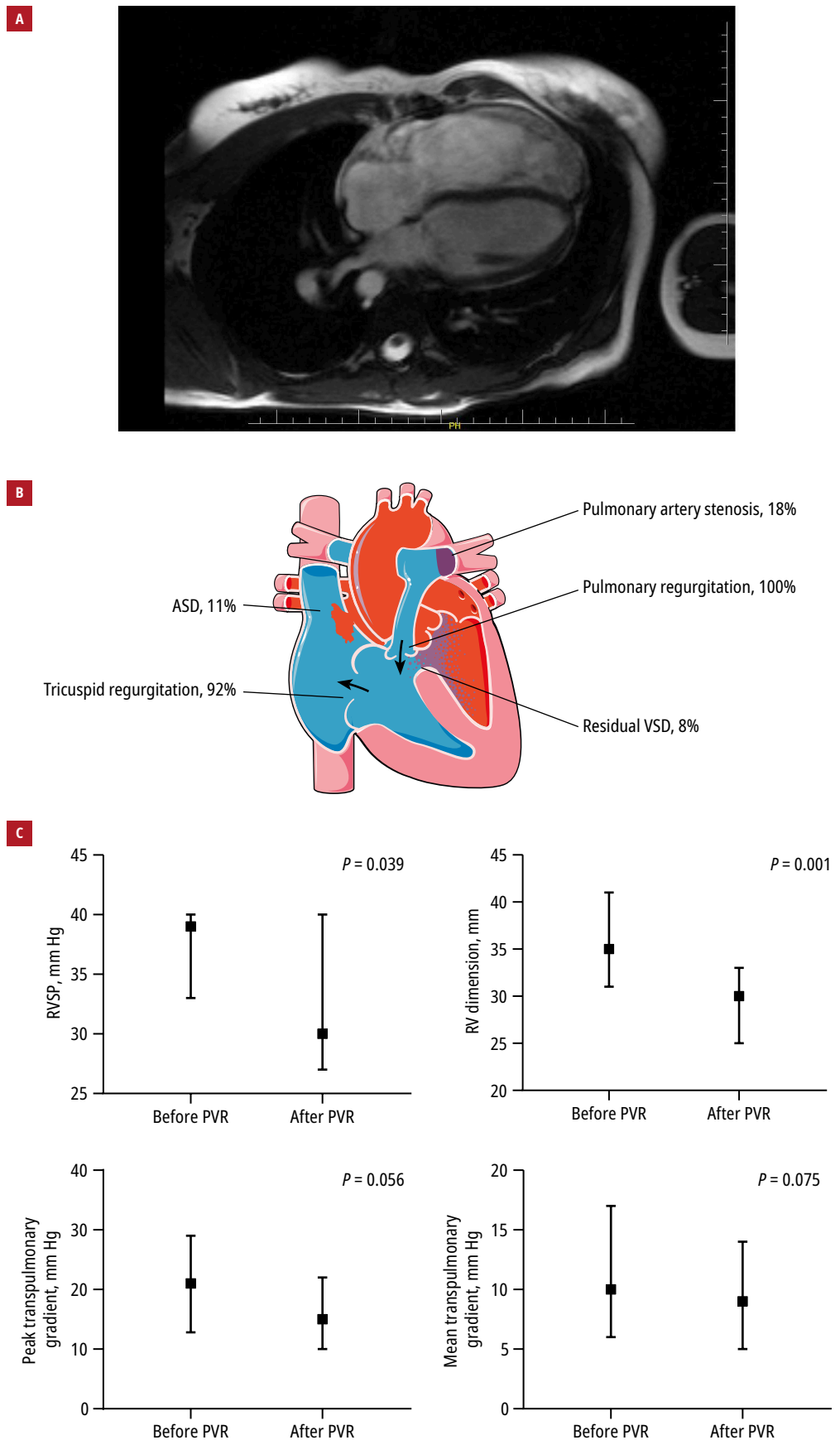
accordance with the current recommendations of the European Society of Cardiology.<sup>3</sup> For asymptomatic patients, we maintained a proactive approach towards PVR. In all patients, we performed cardiac magnetic resonance imaging (MRI) as part of preoperative evaluation (FIGURE 1A). The RV end-diastolic volume (EDV) of 163 ml/m<sup>2</sup> and RV end-systolic volume (ESV) of 80 ml/m<sup>2</sup> were used to guide the decisions regarding PVR in asymptomatic patients.<sup>4</sup> Ethics committee approval was not required in this retrospective study.

**Operative technique** All patients underwent classic redo sternotomy and were operated using a cardiopulmonary bypass at moderate hypothermia (esophageal temperature, 32°C), using a nonpulsatile roller pump with the blood flow of 2 to 2.4 l/min/m<sup>2</sup> and mean arterial pressure of 40 to 60 mm Hg. For maximum safety, arterial line was placed in the femoral artery prior to thoracotomy. RV remodeling was performed and a homologous pericardial patch (mean dimensions, 8.1 × 5.2 cm) was used. The Sorin Crown (Livanova, London, England) bioprosthetic valve for PVR was used in all cases.

**Statistical analysis** A 2-tailed *P* value of less than 0.05 was considered significant. Continuous variables were presented as median (interquartile range [IQR]) due to the sample size. The Wilcoxon nonparametric test for paired samples was used for comparison of continuous variables, as appropriate.

**Correspondence to:**  
Grzegorz Wasilewski, MD, PhD,  
Institute of Cardiology,  
Jagiellonian University Medical  
College, ul. Prądnicka 80,  
31-202 Kraków, Poland,  
phone: +48 12 614 30 75, email:  
grzegorz.wasilewski23@gmail.com  
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**FIGURE 1** **A** – preoperative cardiac magnetic resonance imaging, transverse plane; **B** – indications for tetralogy of Fallot (ToF) reoperation; **C** – right ventricular (RV) echocardiographic parameters before and after ToF reoperation  
Abbreviations: ASD, atrial septal defect; PVR, pulmonary valve replacement; RVSP, right ventricular systolic pressure; VSD, ventricular septal defect

**Results and discussion** A total of 27 patients with the median (IQR) age of 29 (23–35) years were analyzed. The sex distribution was almost equal (male sex, 14 [52%]). The median (IQR) age at the initial intracardiac repair was 5 (2–9.5) years; the correction was carried out in adulthood in 2 patients (8%). The median (IQR) time interval between the initial repair and reoperation was 23 (19–27) years. The distribution of functional New York Heart Association was as follows: I (n = 10 [37%]), II (n = 11 [40%]), III (n = 4 [15%]), and IV (n = 2 [8%]). The median (IQR) RV EDV and ESV in MRI was 151 (138–169) ml/m<sup>2</sup> and 71 (64–92) ml/m<sup>2</sup>, respectively. Indications for ToF reoperation in our cohort are presented in [FIGURE 1B](#).

**Surgery** Aortic cross-clamp time depended on the need for concomitant procedures (median [IQR], 81 [74–94.5] minutes). The median size of the Sorin Crown bioprosthetic valve in the pulmonary position was 25 mm. In all cases, surgical RV reduction with RV outflow tract (RVOT) and pulmonary trunk remodeling was performed, and in 5 cases (18%), additionally stenotic pulmonary branches arterioplasty using the homologous pericardial patch was carried out. An additional surgical procedure was required in 16 cases (59%): tricuspid valve repair with an annuloplasty ring (n = 13 [48%]), residual ventricular septal defect closure (n = 2 [8%]), and atrial septal defect closure (n = 3 [11%]). The Carpentier-Edwards Physio Tricuspid ring (Edwards Lifesciences, Irvine, California, United States) was used for tricuspid annuloplasty.

**Postoperative period** There were no intraoperative mortalities. One patient (3.7%) died 1 day after the surgery due to multiple organ dysfunction syndrome. The median (IQR) stay at the intensive care unit was 1.5 (1–3) days and the median (IQR) postoperative hospitalization time was 8 (7–9) days. All 26 patients were discharged in the New York Heart Association functional class I (n = 22 [84%]) or II (n = 4 [16%]). After a median follow-up of 4.1 years (range, 2–7.2 years), 26 patients were alive (96.3%). The analysis of biochemical parameters showed that temporary acute kidney injury occurred in 5 cases (19%).

**Follow-up echocardiography** No patients were lost to follow-up. The median (IQR) left ventricular ejection fraction on follow-up echocardiography was lower than preoperatively (60% [59–65%] vs 66% [63.75–71.25%];  $P < 0.01$ ) but still left ventricular ejection fraction was preserved. The RV median (IQR) dimension was significantly lower than in the preoperative period (30 [25–33] mm vs 35 [31–41] mm;  $P < 0.01$ ). The median (IQR) right ventricular systolic pressure on echocardiography after PVR was significantly lower than preoperatively (30 [27–40] mm Hg vs 39 [33–40] mm Hg;  $P = 0.039$ ). The median

(IQR) postoperative peak gradient through pulmonary valve tended to be lower than preoperatively (16 [9–21] mm Hg vs 20 [12–30] mm Hg;  $P = 0.056$ ). The median (IQR) gradient also tended to be lower (9 [5–14] mm Hg vs 10 [6–17] mm Hg;  $P = 0.075$ ). The outcomes are presented in [FIGURE 1C](#).

The bioprosthetic aortic valve used in pulmonary position proved to be a good option. Surgical RV reduction with RVOT remodeling and pulmonary arterioplasty using the homologous pericardial patch provide excellent conditions for RV remodeling. In our study, we used only the Sorin Crown bioprosthetic aortic valve and the postoperative peak and mean transpulmonary gradients were satisfactory.

The optimal timing of PVR, especially in asymptomatic patients, is not clearly defined. There are no universal definitions of severe RV dilation and moderate-to-severe RV dysfunction, and there are no prespecified criteria for qualifications.<sup>5</sup> Several studies using MRI have addressed this issue by reporting cutoff values of preoperative RV ESV and EDV for successful RV remodeling after PVR.<sup>6</sup> According to these studies, the cutoff RV EDV and ESV are about 160 and 80 ml/m<sup>2</sup>, respectively. Those parameters reached similar values in our study. Tissue Doppler echocardiography may show diastolic abnormalities of RV and intraventricular septum and should be considered during preoperative examination.<sup>7</sup>

The operative risk in our study was acceptable and there was one perioperative death. The reported acute kidney injury was transient and the renal replacement therapy was not needed. Subjective improvement of functional status is evident and persistent in our patients. Other techniques of restoring the RVOT were also analyzed and proven to be effective, but if a valvular intervention is required, a bioprosthesis is favored and is superior to a mechanical valve.

**Study limitations** This study has all limitations of a single-center retrospective observational study. Sample size is limited, yet this is the largest Polish cohort reported to date.

In conclusion, reoperation in young adult patients after classic ToF repair in childhood with PVR using a bioprosthetic Sorin Crown valve has proven to be safe with good early- and long-term outcomes.

## ARTICLE INFORMATION

**CONFLICT OF INTEREST** None declared.

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